Neptune-WP2 (imaging)

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Goals of WP2 (imaging)

- Evaluate bio-distributions of fluorinated tracers using ^{19}F-MRI
- ^{19}F-MRI performances limited by low SNR ratio
- Possible **hardware improvements** to ^{19}F-MRI
  - low noise RF coil
  - software defined radio technology for signal digitization
  - new pre-amp & cooling

test-stand: 0.35 T scanner

- Possible **sofware improvements** to ^{19}F-MRI
  - use of deep learning to denoise and analyse images
- Choice of fluorinated molecules
  - tests on animals to have samples with correct concentrations

9T spectrometer

Activities 2019/2020-ongoing

- New antenna
  - Design/construction

- Sofware Defined Radio system
  - Installation/implementation/readout optimization

- Mice tests
  - animal test protocol approved 6/11/19
  - mouse healty pancreatic tissue characterization in MRI
  - choice of the fluorinated tracers

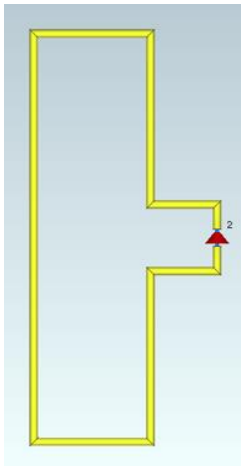
- AI algorithms
  - preliminary development on simulated data
  - noise study on low SNR ^{1}H-MRI images
  - in-vitro measurements with ^{19}F micro-imaging

^{19}F probe for micro-imaging purchased, tuning to be done

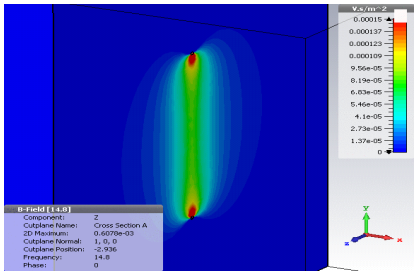
New antenna

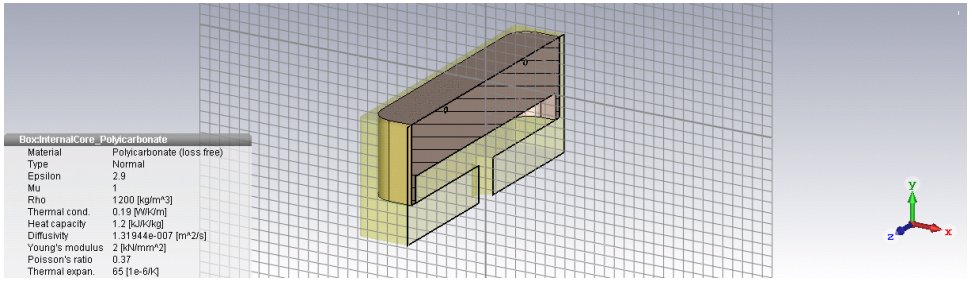
L. Ficcadenti

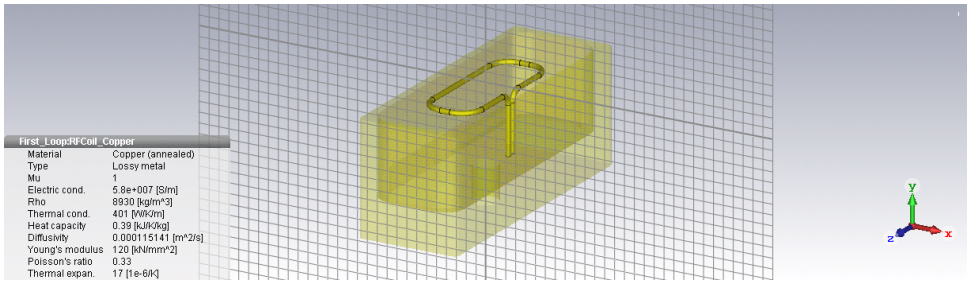
- Design optimization using CST simulations
- Tuning and matching circuits
- One loop Cu 1 mm antenna prototype under construction
  - Al case built
  - housing with selected NMR compatible material under construction with 3D printer

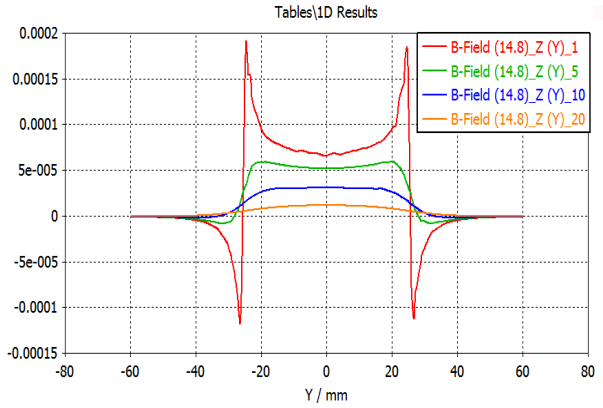


- **Next**: test with the 0.35T scanner, tuning, characterization in terms of noise, noise study of the pre-amp







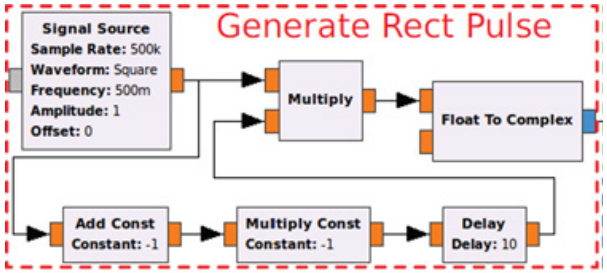


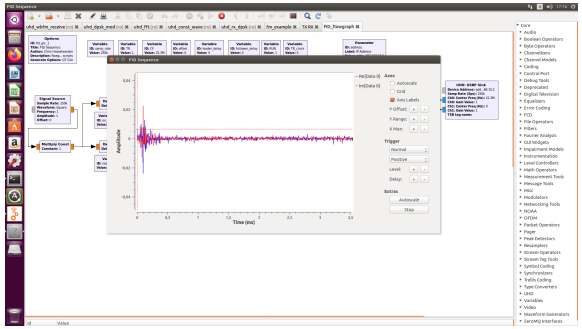
Software Defined Ratio System

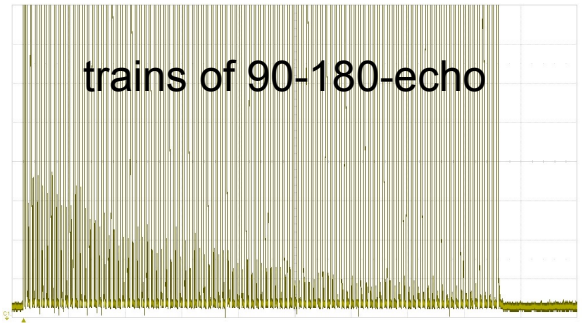
V. Bocci, D. Carlotti
E. Furfaro,
F. Iacoangeli

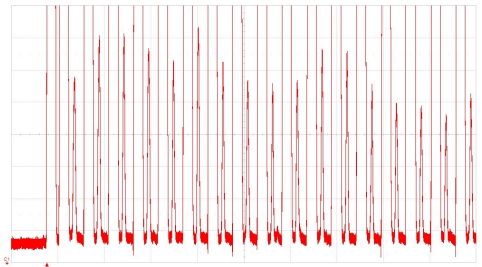
- Allows optimization of MR signal via software algorithm (as opposed as via hardware components as usual)

- **Status**
  - implemented the open source SDR package gr-MRI for MRI
  - implemented a working generation-reception chain of MR signal (gr-MRI supports generation of 4 MR excitation sequence, multi-radio synchronization, MR signal processing and image reconstruction)
  - acquired real signals from the real spectrometer for read-out optimization







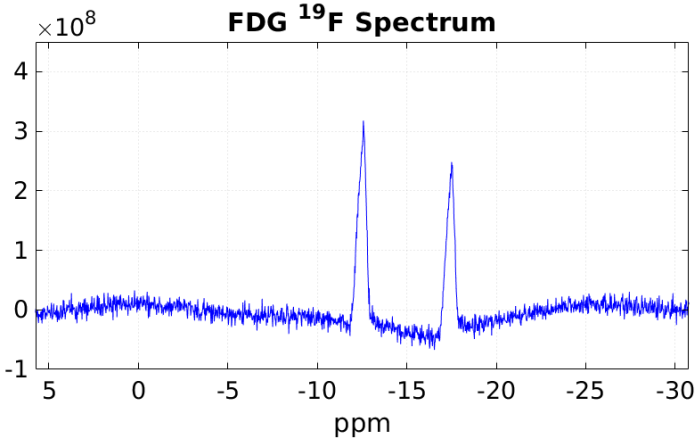


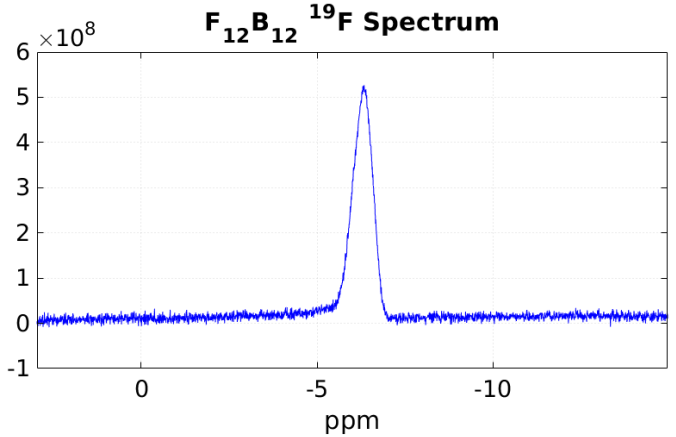
MRS study of fluorinated compounds

S.Capuani

- 4 different fluorinated molecules were taken into consideration and studied in MR-Spectroscopy

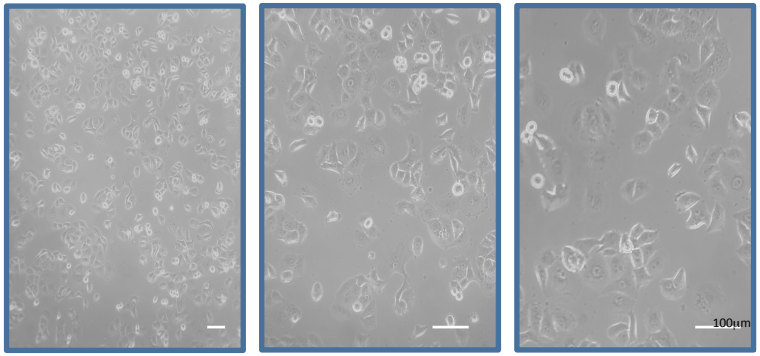
- FDG <= not ok for imaging (double peak in MRS)
- 5F-phenylanalina <=not ok for imaging (multiple-peaks in MRS)
- **F-BPA** <= **ok for imaging, contains B, internalized by PANC, not cytotoxic: we will use it for animal tests and we propose it for radiobiological tests**
- $F_{12}B_{12}$ <= ok for imaging, not ok for internalization, toxic



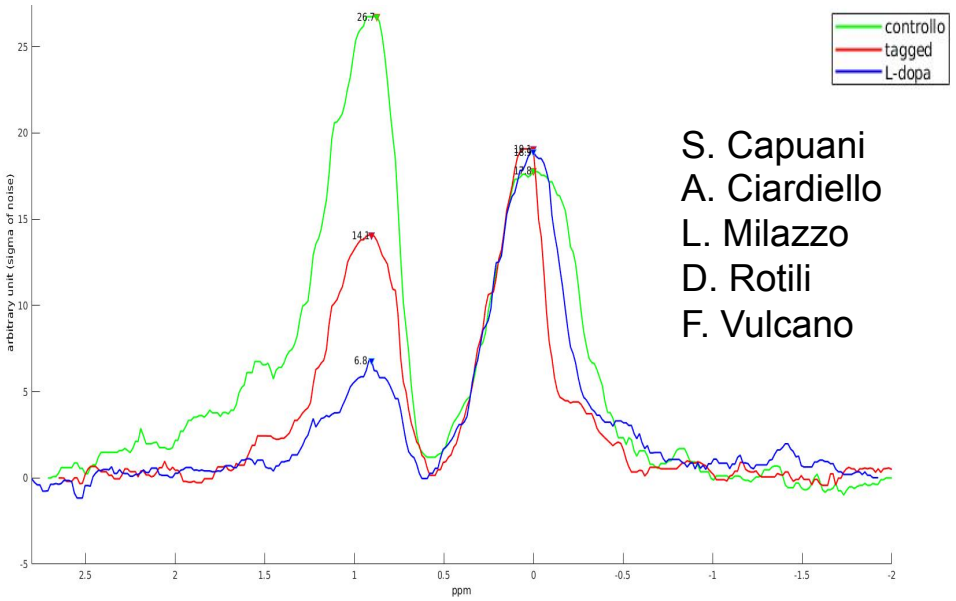


F-BPA

PANC-1 2x10^6 cells/1T75 24h semina(10X)



1x 2x 2,5x



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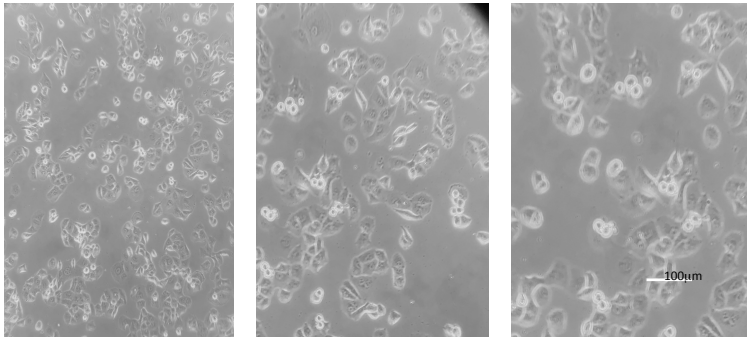
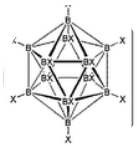
PANC-1 dopo incubazione 4h F-BPA



1x 2x 2,5x

- F-BPA 13.6 mM/4h incubation internalization: C_{int} ~0.5C_{ext} in qualitative agreement with Pavia/Caserta
- Preloading con L-dopa 5mM/4h before incubation does not improve the internalization

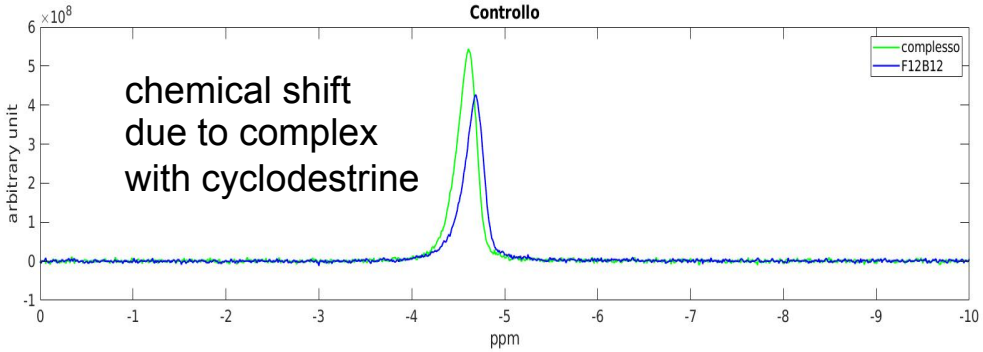
$F_{12}B_{12}$



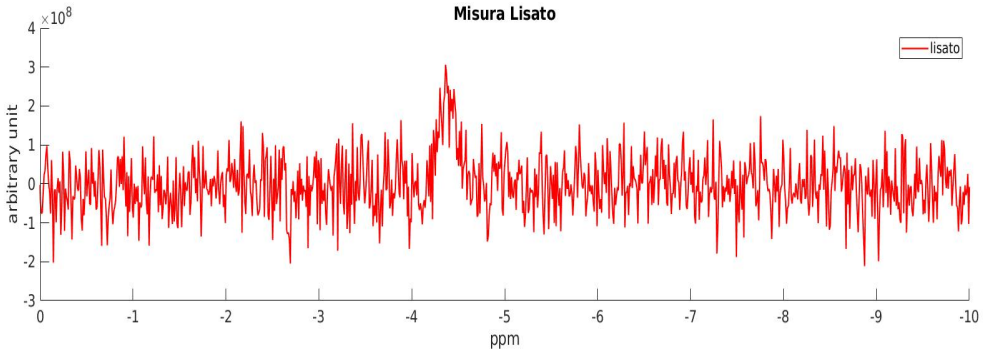
- $F_{12}B_{12}$ at 1.2 mM (equivalent to ^{19}F atom concentration used in F-BPA)
  in complex with β-CD / 22h incubation (PANC1)
  - No significant internalization

- Cytoxic at 13.6 mM (x 12 in ^{19}F atom concentration used in F-BPA)

- Check on fibroblasts: $F_{12}B_{12}$ 1.2 mM in complex con β-CD / 22h incubation
  - internalization observed in agreement with literature.

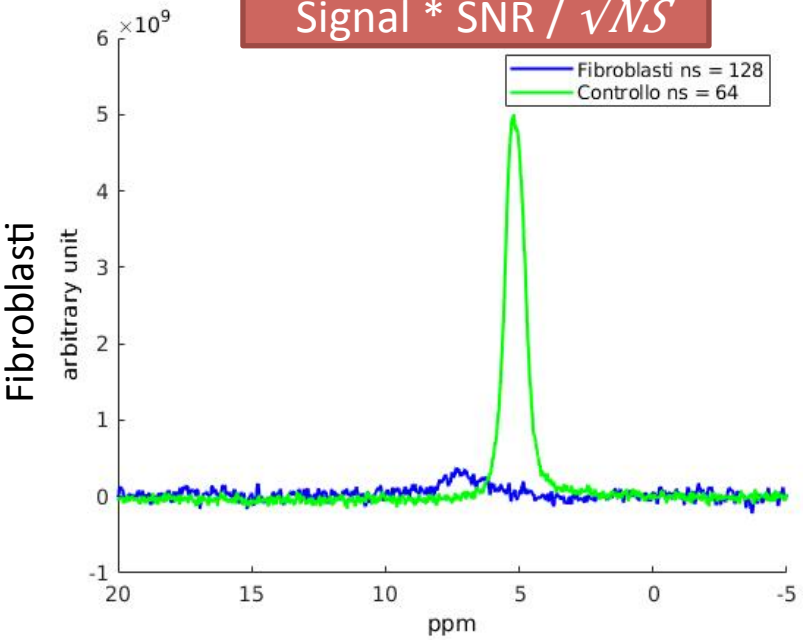


PANC



Signal * SNR / $\sqrt{NS}$

Fibroblasti

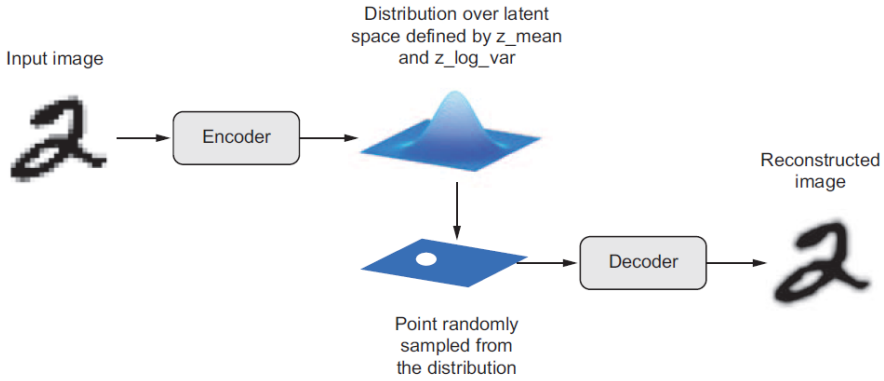


Denoising AI algorithm

A. Sbandi
S. Giagu

- Different architecture tested on a high statistic sample of simulated images with low SNR ratio (Rician noise)

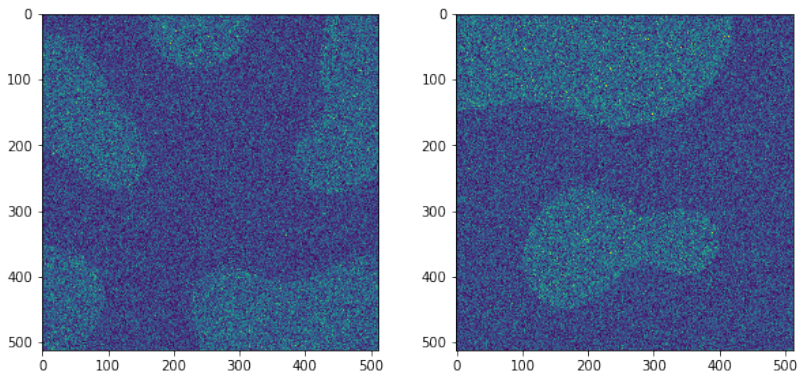
  - Denoising Autoencoder (DAE)
  - Variational Autoencoder (VAE)
  - Denoising Convolutional Neural Network (DnCNN)

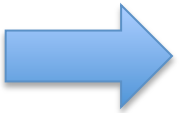


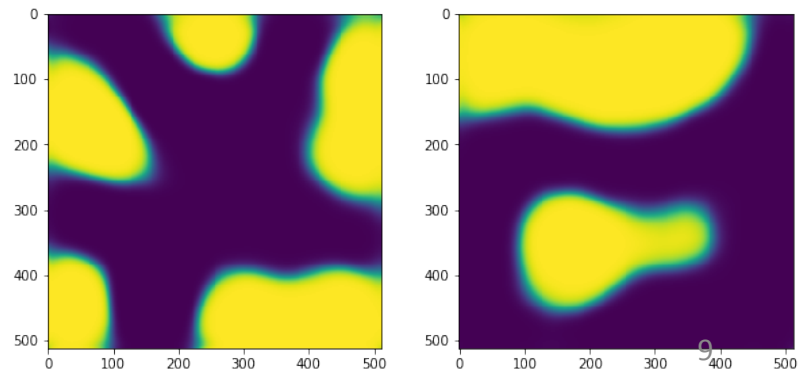
PSNR = 5.86 ± 0.33
Dice Coefficient = 0.334 ± 0.008

VAE

PSNR = 14 ± 1
Dice Coefficient = 0.913 ± 0.017

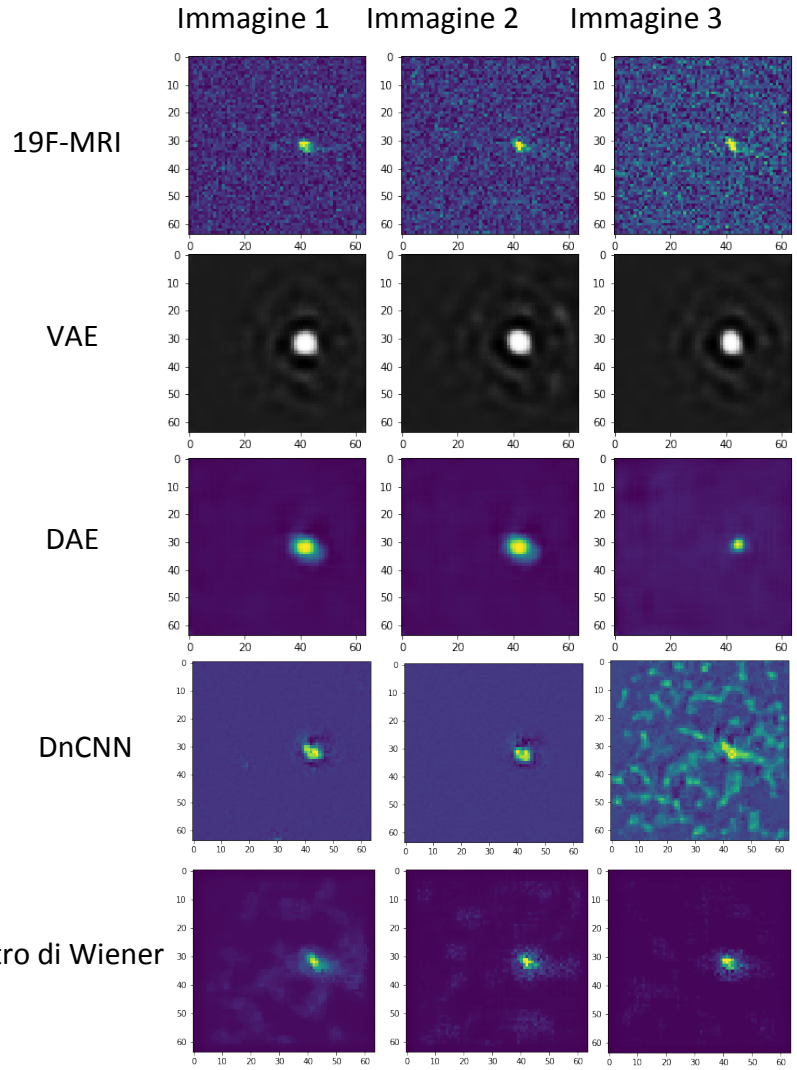






Results on real ^{19}F-MRI images

- Algorithms tested on few real ^{19}F images from an old Silvia's work
- DnCNN removes well the noise (as Wiener filter)
- Wiener leaves some structures , maybe non-Rician noise components

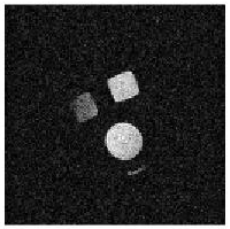


Shannon entropy

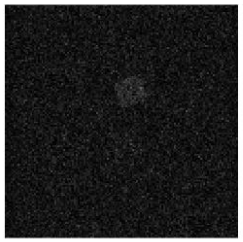
	MRI 1	MRI 2	MRI 3
DAE	11.996	11.995	11.997
VAE	11.982	11.981	11.988
Filtro di Wiener	11.999	11.999	11.999

Low SNR signal study

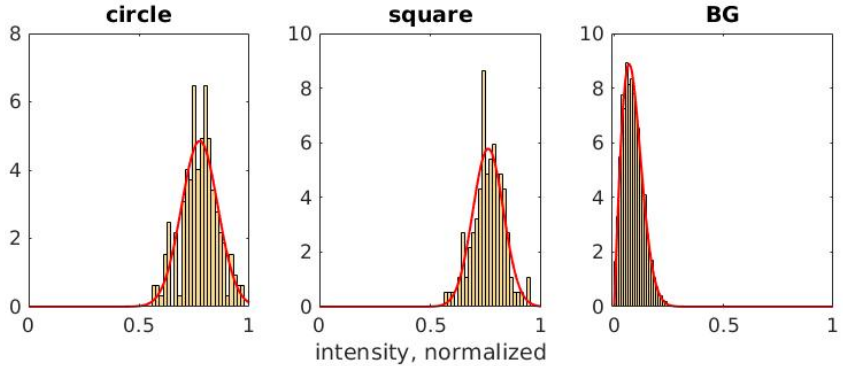
- Acquired in vitro ^{1}H-MRI images with low SNR ratio
- Since $S = S_0 \exp(-TE/T_2)$ => at high TE we obtain low SNR images
- We planned to use these data to test the AI algorithms

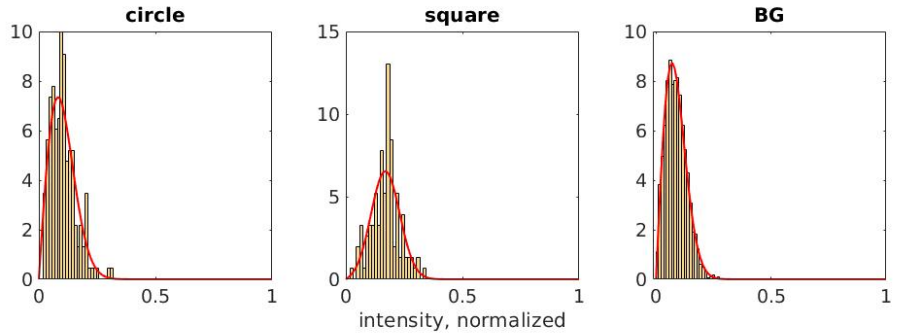


Small TE,
high SNR

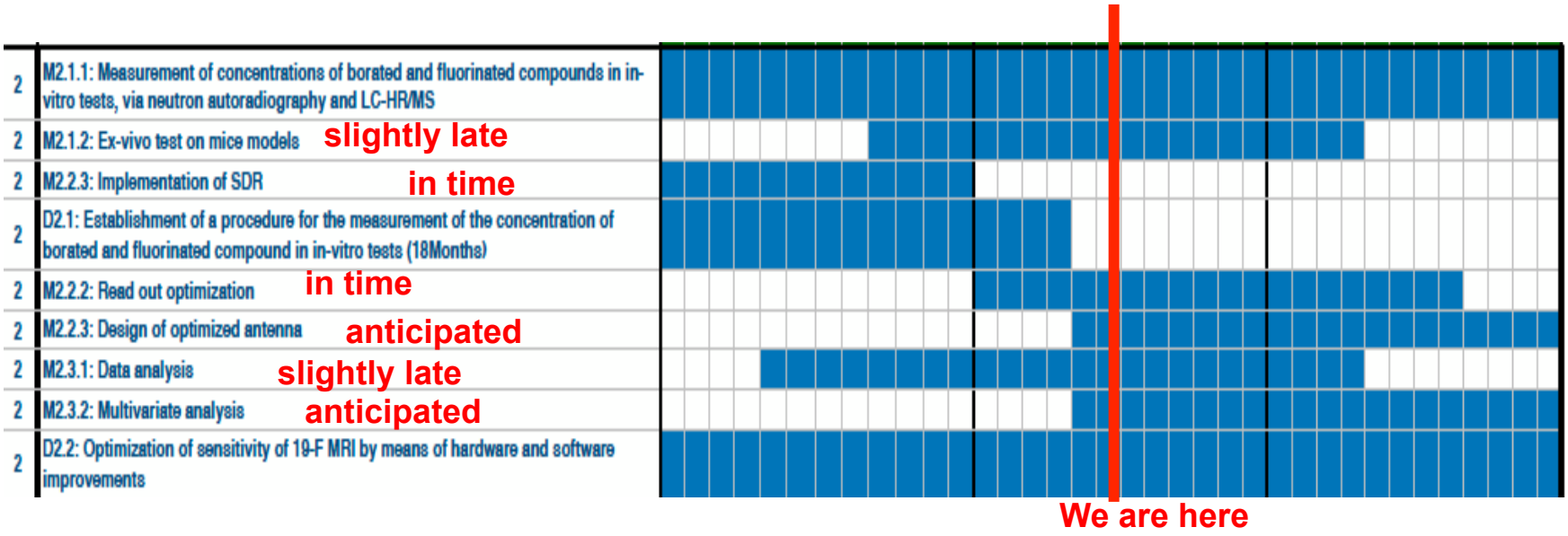


Big TE
low SNR





Milestones



	September 2019 (%)	Now (%)
M.2.1.2	0	30
M.2.2.1	50	100
M2.2.2	0	30
M2.2.3	30	100
M2.3.1	20	30
M2.3.2	20	40
D.2.2	20	40

Bilancio e Preventivi

Bilancio 2020

Missioni: avanzo 1.8kE => non penso ne avremo bisogno

Assegno: procedura partita

Consumo: avanzo 2kE, 6kE s.j.
- acquisti da fare: 0.5kE SDR, 0.5kE materiale di consumo di laboratorio
- sbloccando parte del s.j. (~3.5kE) potremmo avviare la procedura
  di acquisto di altri 20 topi in modo da poter chiedere la consegna
  gia' i primi mesi del 2021

Apparati: 20kE s.j. (5 pre-amp, 15 criogenica)
=> sicuramente non sblocchiamo la criogenia,
    forse non siamo in grado di dare una risposta sul pe-amp quest'anno

Preventivi 2021 (dal proposal)

Assegno: 28.5kE

Missioni: 3.5 kE

Consumo: 10kE topi (possiamo diminuire un po' se compriamo altri 20 topi quest'anno)
3kE tracers

Apparati: 0 (spostare il s.j. almeno per preamp?)